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Book review

Jeff Hawkins and Sandra Blakeslee, On Intelligence, Times Books, 2004.

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The brain is an awesomely complicated system, arguably the most complex in the Universe. The problems of understanding it are exercising the minds of tens of thousands of neuroscientists around the world. I use the word 'problems' in the plural since there are many levels at which the brain can be tackled: at the level of synapses, of neurons, of columns of neurons, of modules, of the different networks of modules employed by the brain in different tasks, and finally at the level of the global brain itself. With the advent of brain imaging machines and ever more delicate single cell electrodes, as well as with new investigative methods becoming available, such as trans-cranial magnetic stimulation or infra-red imaging, the understanding of the brain is moving forward at these different levels ever faster. But could we be swamped with this tide of experimental data? Could we be finding it ever more difficult to see the wood for the trees of the brain?

It is obviously true that it will be difficult to understand the global brain by building ever more exact models of single neurons, or even of single columns of neurons. Even an exact model of a single module would not allow us to extract the principles that may be operative at the level of the global brain. So how can we best proceed to understand the brain globally? One approach I have advocated [5] is to start at a global level, with simplified neurons and their learning rules, and subsequently make the single neurons and the connectivity between modules ever more complex. However the first, relatively simple stage should be able to allow the analysis and deduction of possible global principles and resulting patterns of activity. It should thereby allow the wealth of global brain data arising from brain imaging to be begun to be understood. However the manner in which this is best achieved is still unclear, although various groups are beginning to move along this route.

It is this approach—start global, go ever more local—which is also espoused in the book under review by Jeff Hawkins. He writes simply but with conviction about his vision of the principles of the global brain. He concludes in the middle of the book that it is a 'hierarchical memory system', in which prediction plays a crucially important role.

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He expands on the hierarchical aspect in terms of the visual system (more specifically the ventral, object-based visual route to anterior temporal lobe and prefrontal cortex). He even develops a detailed model of how sequences could be stored in the 6-layered hierarchical cortex. This is a tour de force, and one of the gems of this very stimulating book.

However it is in the implications of this somewhat restricted vision of the global brain that the gaps show up between the vision and reality. The real brain has various important control systems to enable more efficient action responses, and even both they and sensory processing use what are termed 'internal models' of the external world to be more efficient. These internal models are at the basis of prediction, but seem missing from the description of Hawkins. In particular, the faculty of attention may be the crucial control element [4,6], in which internal models of the attended state are created through buffer working memory sites, enabling thinking and planning to be achieved. Even consciousness, I claim, could thereby emerge.

Here is where I diverge completely from Hawkins' global view of the brain. Without such an attention 'filter' process the external world, as represented in the brain, would be a vast and chaotic mess. It would consist of the items of interest but also many distracters. Attention filters these out, and leads to the attended state of the world as a filtered state (containing the desired object, place or action) alone on a buffer working memory site. It is this process of selection which, I claim, has been elevated by evolution to the highest and most precise instrument in the human brain as compared to those of 'lower' animals (as evinced, for example by the highest number of varicosities for targeted release of the crucial attention modulator acetylcholine being in humans as compared to other animals). It is also a crucial component of consciousness, providing the detailed content to experience.

However I diverge even more from Hawkins' vision of the global brain over consciousness. To me this is a real attribute, created, beyond pure content, by the presence of a precursor attention control signal helping the emergence of the attended state of the world on the working memory buffer for content. This attention control signal is now emerging from the experimental shadows, beginning to be seen in several MEG experiments and also by EEG. This precursor signal contributes the 'ownership' experience to the overall conscious content. Even more especially it gives the sense of 'I' (as owner). There is more, especially the attribute that you cannot be wrong if you claim 'I am in pain': I cannot then ask you 'Are you sure it is you who is in pain?' Of course it is you, and nobody else. That immunity to error by misattribution of the first person pronoun, a feature noted already by the American philosopher Shoemaker [3] is naturally brought about by the mechanism of the precursor signal I have suggested.

Moreover the precursor signal in motor control is well known: it speeds up error correction in the making of actions. On my view, consciousness (the 'what it is like to be' of [2]) is a crucial component of the control feature of attention, allowing for similar speed-up both of error correction and of learning better attention control (and the learning of attention to objects is no mean feat in the infant). Thus consciousness has a crucial control role to play; it is not an epiphenomenon, as some have claimed, and as Hawkins seems to agree.

There is also the question of the discussion by Hawkins of the ethics of building an intelligent 'brain-based' machine. We see around us in society the increasing difficulty of bringing up children who do not become a danger to others in society. This arises, I suggest, from a lack of proper, possibly early, parenting. But what is good parenting but instilling into one's offspring a framework of discipline, instilled in a loving environment, from which an adult can spring forth who finds value in life and is empathic to others?

How can this be achieved? I have suggested [7] that one way to achieve this is through a loving upbringing in which the word NO is learnt even before speech begins. How else should we create an ultra-intelligent (or even moderately intelligent) machine except by using similar methods? This requires developing reward maps of the external world in the artificial brain. Such reward learning as seems to occur in the human brain (based on dopamine modulation in prefrontal cortex and the limbic region) is already being modelled with ever greater value in a variety of robotic control system [1]. It will have to be fused with the attention control system I mentioned earlier before we should unleash on the world robots controlled by cognitive brains.

So what is my final assessment of Hawkins' book? It is a valiant stab at a difficult problem. It makes a stimulating read. But it is misguided in claiming that it solves the problem of the global brain. The principles of an effective global brain, one for example able to safely control an autonomous robot brain, are, I would suggest:

(a) Attention control, with associated internal models leading to consciousness as the highest level of cognitive control, used in speeding it up, and leading to the sense of 'I';
(b) Memory systems able to store attended experiences from the environment and use them, either initially under attention or ultimately automatically for efficient responses;
(c) Reward prediction systems, somewhat independent of the attention and memory systems, but functioning so as build reward maps of the world, so leading to ability to plan action leading to the greatest rewards; these should also contain the command 'NO' as for human infants, although expressed in terms of a suitable penalty as the opposite of a reward.

Thus memory and prediction play important roles in my view of the global brain, as Hawkins emphasises, but only in a more complex manner (both as episodic and semantic, and as procedural or skill learning). But these components are under the overall control of attention, which itself is spurred on by consciousness. Hawkins thus emphasises memory, but gets it wrong in claiming that it is the same as 'forming declarative memories' (although declarative memories are generally defined as having the sense of 'I' attached, and Hawkins nowhere addresses what an 'I' is like or how it would be created neurally—neither 'I' nor 'self' are in his index); he takes little notice of reward or emotions, and he neglects attention as the most important brain control system, and the gateway to consciousness.

So read Hawkins book by all means but realise that there are (many) other views of the global brain and its consciousness, some of which are based on a more detailed view of the data now emerging; I have presented an alternative one.

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